Physics

MODELING FAILURES IN THE NORTH AMERICAN POWER GRID

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As demonstrated in August of 2003, local disruptions of power distribution within the North American power grid can result in the loss of service to tens of millions of customers. Using data about the network structure of the North American power grid, this research involves a simulation that removes nodes and monitors the grids network properties over a period of time following a node removal.

The node substations are generators, transmitters, and distributors and there are two removal schemes: highest-load based and random based. By removing single nodes and varying nodes' tolerance values, i.e. the ability of a node to handle increased capacity and resist failure, we found that a critical value in tolerance exists above which the system is stable. The random based removals are more resistive to failure and suggest two further subdivisions for nodes based on their degree, the number of incident edges to a node, and betweenness, the node load. Interestingly, it was observed that the highest-load randomly selected node did not affect the network upon removal as much as a less highly loaded node. When modeling cascading failure, successive node removals with network evolution between each removal, we found that the first removal, both load and random based, was the most destructive to the network efficiency, a measure of how efficiently the network transfers power between two nodes. Past the first removal, the decrease in efficiency was small with the transmitters load based removal decreasing the largest amount. For random removals, a stable, oscillating behavior past the first removal was also seen.

Our research has produced interesting findings about the network structure and stability of the North American power grid. Further areas of study include examining the oscillating behavior seen the cascading failure, tracking the progression of a failure through the grid based on node characteristics, and examining the distribution of damage caused by node removal.

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